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January 4, 1961

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HALL EFFECT CURRENT

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Gentlemen:

The enclosed information constitutes the instruction manuals for Item C of the subject project. On December 30, 1960 one clamp on Hall Effect sensor with amplifier (Item C) and the remaining amplifier of Item B were shipped under separate cover. The shipment was made in accordance with the same arrangements which had previously been made with your technical personnel for Items A and B. An additional five (5) copies of the paper, "Magnetic-Field Pickup for Low-Frequency Radio-Interference Measuring Sets" is enclosed since it is referred to in the instructions.

Since, the clamp-on probe had an opening of less than half an inch in diameter, we intend to ship to you another one with a larger diameter. We hope to have it ready within less than two weeks. The main unit has a built-in audio filter which requires a high input impedance indicator. Detailed instructions and description of the system are enclosed.

The other auxilliary unit for the magnetometer probes is identical with that already shipped on November 4, 1960. The magnitude of the calibrator output should be the same as in the previous one, within better than five percent. This can be checked by interchanging the magnetometer probes with both units and observing the outputs during the calibration procedure. The frequency of the calibration signal is somewhat higher than in the first unit; however, this should not cause any difficulty in operation.

As shown in the instructions, the limit of sensitivity of the clamp-on probe is of the order of 10 microamperes. It has been found that the main difficulty arose from an increase in noise in the device with decreasing thickness.

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The non-uniformities in the crystal wafer resulting from the process of preparation of very thin samples cause an increase in noise which cancels the advantages obtained with a thinner semi-conductor and a smaller air gap. It is believed that if additional effort were to be devoted, substantial improvements could be obtained. It is estimated that at least six months would be required to perform the necessary investigations. They should consist of improved methods of lapping, use of higher permeability materials and methods to eliminate the excess noise. If these improvements are considered worthwhile to you, we would be pleased to send a proposal covering this additional activity.

We hope that the equipment and instructions are satisfactory and we would be happy to assist you further in any manner which you desire.

Very truly yours,

[redacted]

Assistant Director
Electronics Research

SIC:bg
Enc. "Hall-Effect Current Clamp - Instructions" (5)
"Magnetic-Field Pickup for Low-Frequency Radio-Interference Measuring Sets" (5)

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HALL-EFFECT CURRENT CLAMP

INSTRUCTIONS

The clamp-on current sensor consists of a Hall element placed in a gap of a ferrite toroid. The ferrite material is ferramic type-H made by General Ceramics. The material is the same as that used in the flux collectors of the magnetometers and is described in the paper enclosed with the previous instructions for the magnetometers. (Another copy of this paper is enclosed with this set of instructions.) The Hall element is placed in a sandwich of ferrite wafers and the toroid is tapered to its size. This construction is also similar to that employed in the design of the magnetometer.

The whole structure is cast in Scotch-Cast and after drilling a hole the entire assembly is cut in two parts and the toroid cross-sections are lapped to minimize the gaps. The clamp can be opened by sliding a plate into two grooved pins. A spring underneath the sliding plate assures that the clamp is tightly closed and thus decreases the gap between the two halves.

The sensitivity of the sensor is approximately 10 microvolts per milliampere of current measured. The bias current is about 150 ma for such a sensitivity. The noise level, through a band pass filter between 300 cps and 3,000 cps is less than 10^{-7} volt. Thus, a measurement of 10 microamperes can be obtained with a signal-to-noise ratio of better than one-to-one.

The probe is supplied with two cables. One cable, consisting of a pair of twisted wires electrically shielded, supplies the bias current to the probe and should be connected to the socket marked "Bias". The other cable, which connects the output of the probe to the amplifier, is a low-noise Microdot coaxial cable furnished with a Microdot plug. This cable is to be connected to a socket marked "Input", on the panel of the main unit. A BNC socket, marked "Output", on the panel of the main unit provides the connection to the output of the amplifier.

The unit is supplied with a bandpass filter in the frequency range of 300 cps to 3,000 cps. While the output impedance of the amplifier is only 600 ohms, the output of the filter is a very high impedance and to assure proper frequency response, in the case of filter "in", the output should be connected to a high impedance indicator. The filter has an approximate voltage gain of two and a half.

After connecting the cables of the probe to the proper sockets on the panel of the main unit, and the output of the main unit to an appropriate indicator, (with a high input impedance for the filter "in" position), and to an oscilloscope, the following procedure should be observed:

1. Turn the amplifier switch-attenuator control from the OFF-position to 0-db setting.

2. Turn on the Bias switch.

3. Turn the Bias adjustment all the way clockwise. (This gives maximum bias current.)

4. Clamp the probe around the conduit the current of which is being measured.

5. If the signal on the oscilloscope indicates distortion of the expected waveform, such as clipping, reduce the bias current or turn the attenuator switch to -20 db or -40 db as required.

The gain of the amplifier is 60,000 at 0 db setting, 6,000 at -20 db and 600 at -40 db respectively. It saturates at .25 volts rms output or over. At maximum bias current at 0 db setting of the attenuator, the system may saturate at 250 microamperes of the measured current. Reducing the bias current to minimum and the attenuator setting to -40 db should permit the undistorted measurement of currents up to 100 milliamperes.